

FP12 Upper-tier Moderator Brightness Measurement and FP12 Guide Performance

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P-23

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Lujan seminar

Acknowledgement

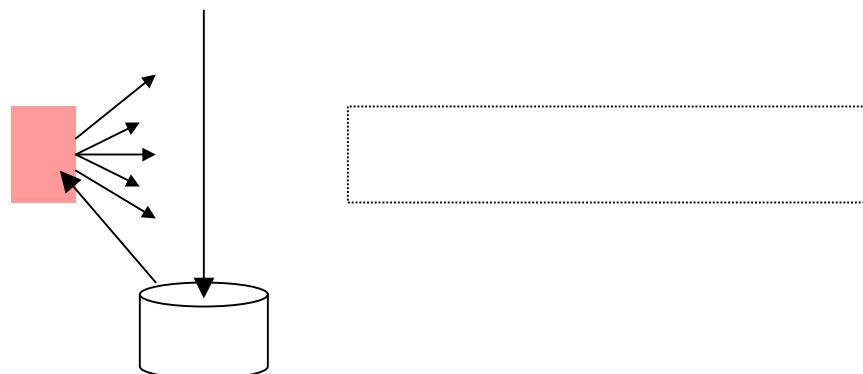
- **Measurement:** J. D. Bowman, M. Gericke, G. Greene (UT),
J. Long(LANSCE-3), G. Mitchell, S. Penttila,
G. Peralta, P.-N. Seo, and W. S. Wilburn
- **Cave construction support:** LANSCE-3 and LANSCE-12
- **Safety interlock system:** LANSCE-6

Goals of the Measurements

1. FP12 upper-tier moderator brightness(never measured before)
2. Study of guide performance
3. Guide alignment

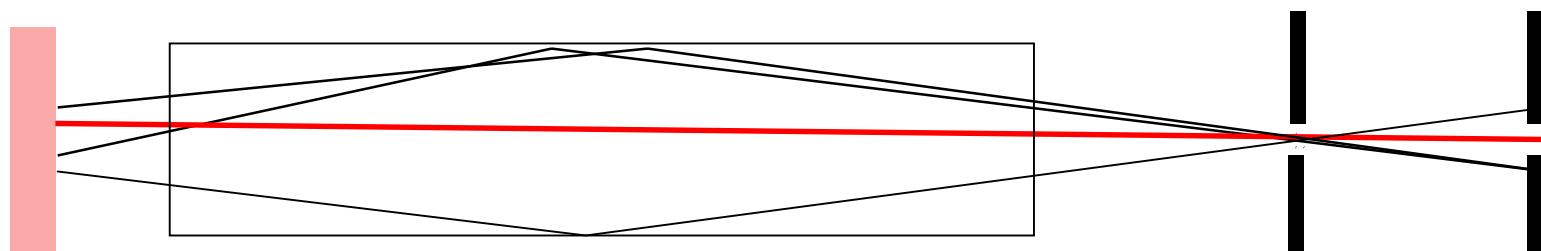
What is Brightness?

1. Brightness is a measure of moderator performance
2. Brightness does not depend on the guide
(neutrons coming directly from the moderator)
3. Brightness depends on source parameters
4. Unit of brightness is “neutron/s/cm²/sr/meV/ μ A”



Why do we need two pin-hole system?

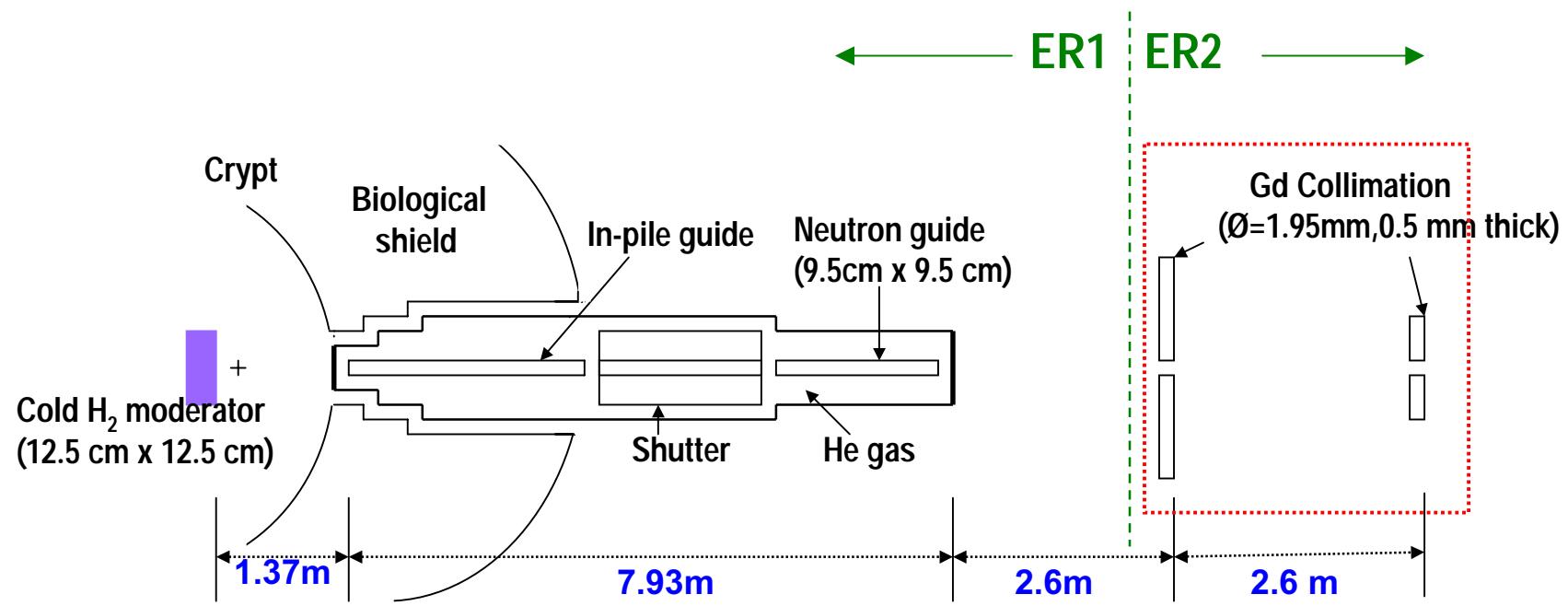
1. Define the area of the view on the moderator
2. Define the solid angle
3. Making count rate countable



When two pin holes are lined, brightness does not depend on the guide and detector views only direct neutrons from the moderator

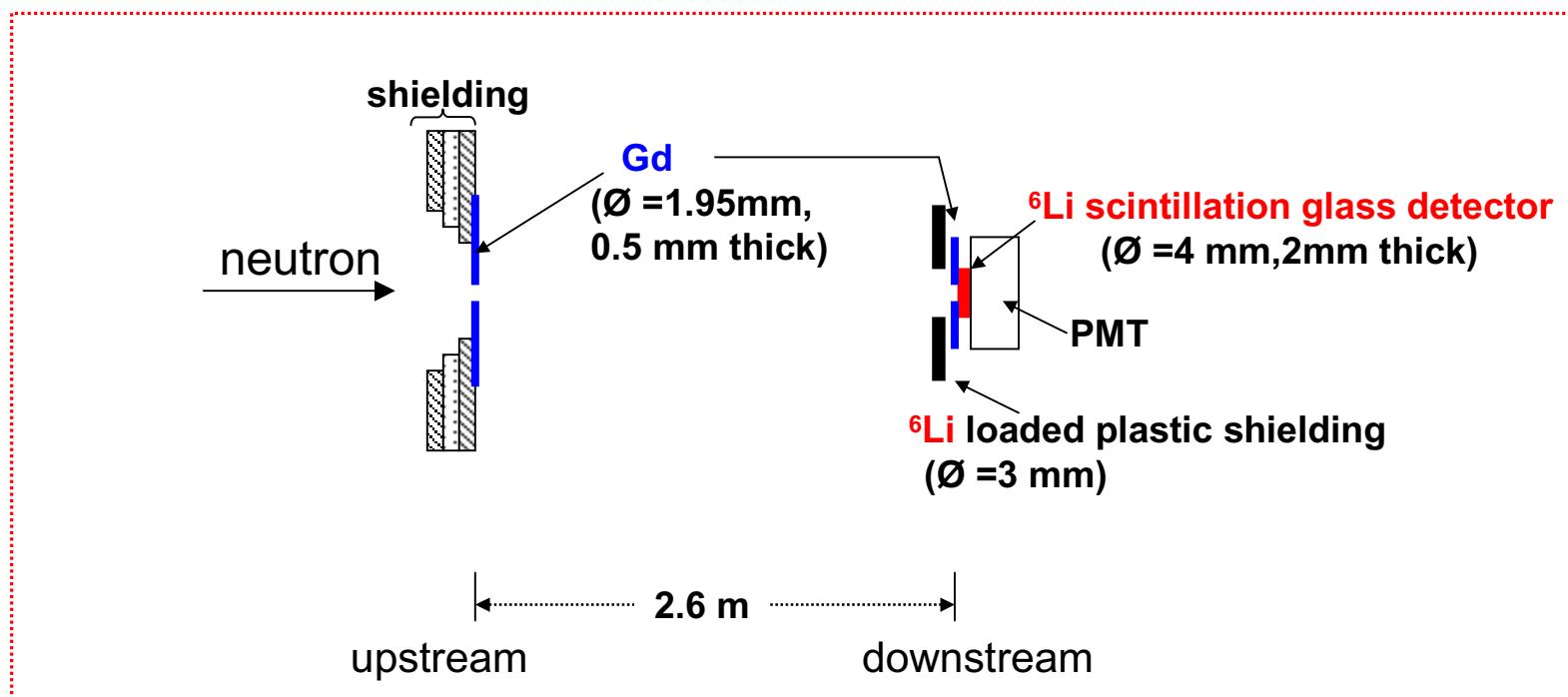
FP12 Beam-line Arrangement and Experimental Layout for Moderator Brightness Measurement

(Top view and not to scale)



Al window entrance/exit: 3.17/1.0mm

Shielding and Collimators (not to scale)



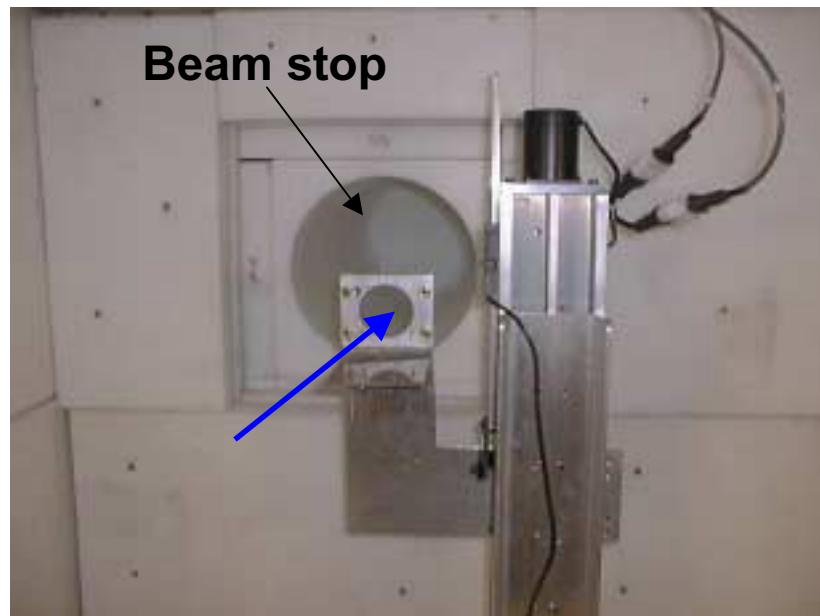
1. Precisely-known **Gd** collimators define acceptance
2. **${}^6\text{Li}$** glass neutron detector: ${}^6\text{Li} + \text{n} \rightarrow \text{triton} + \alpha$

Temporary Cave structure in ER2 for Moderator Brightness Measurement (January 9 -14, 2003)

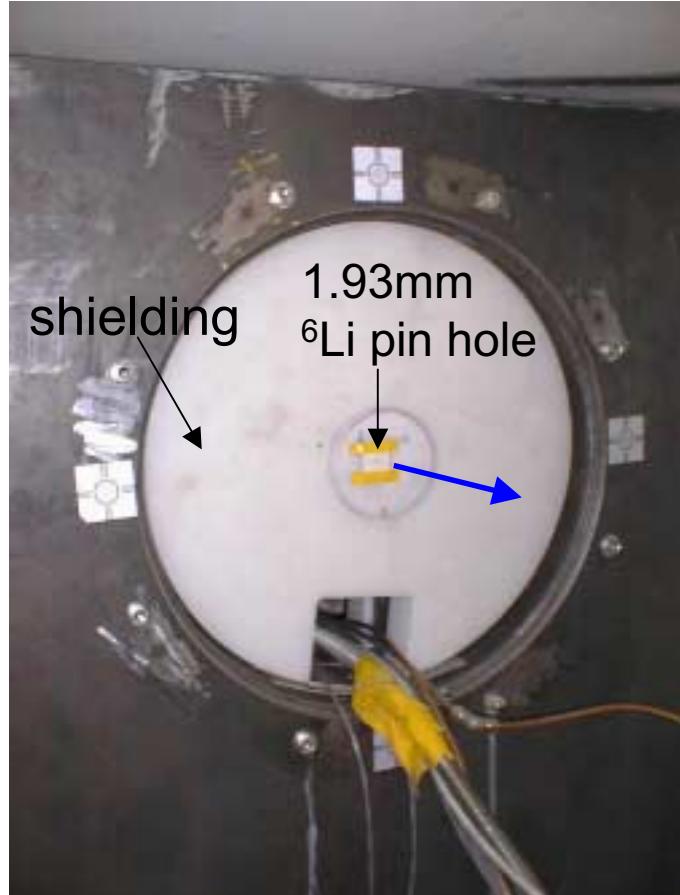




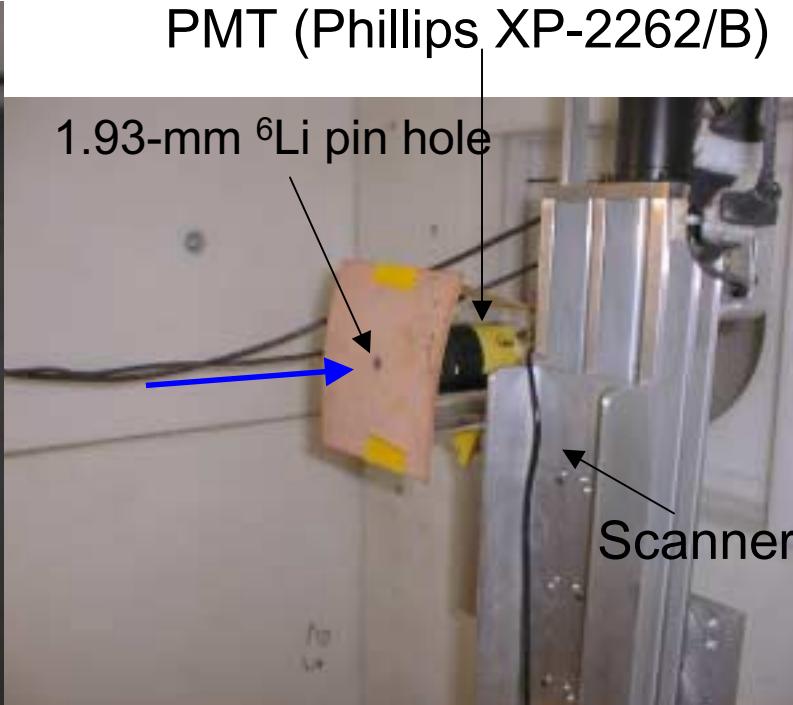
Aligning for upstream pin hole
(~1mm accuracy respect to
the center of the guide)



Preparing PMT mount on a X-Y scanner



Upstream pin hole setup



Downstream pin hole setup

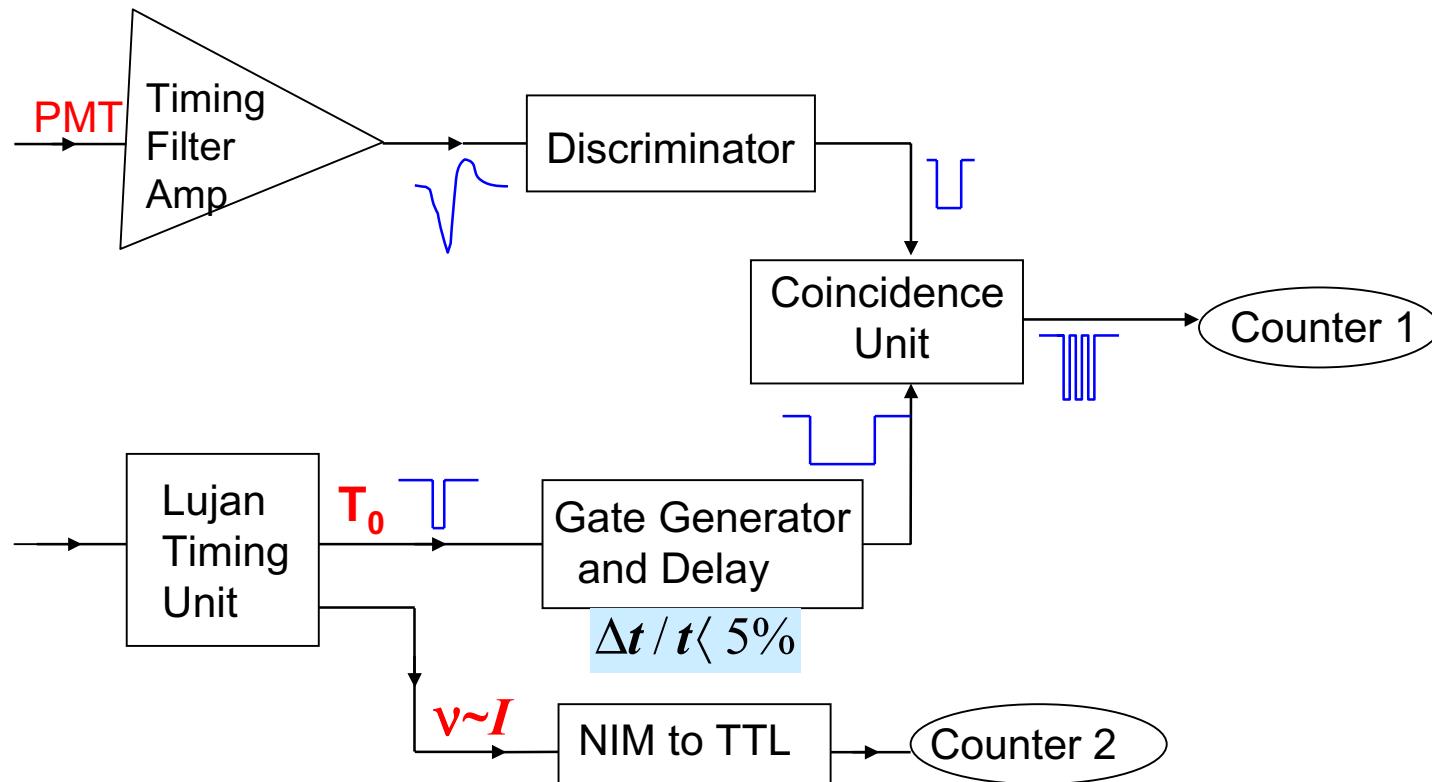


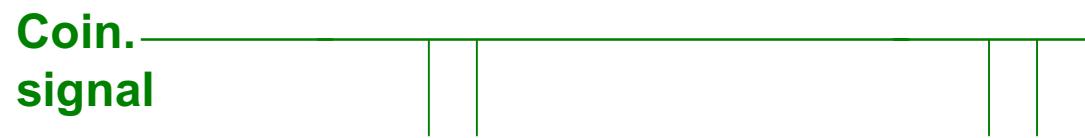
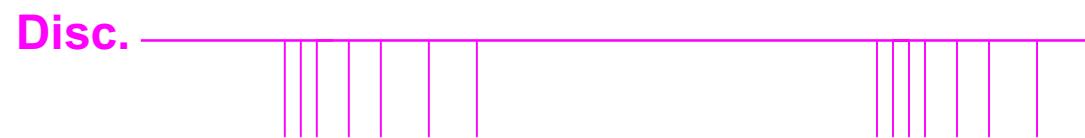
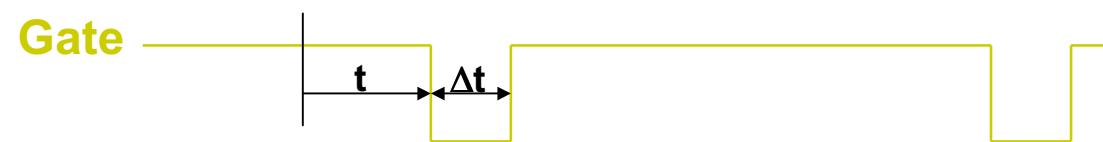
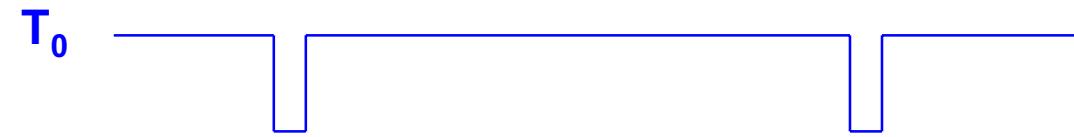
The moment to open the shutter
for FP12 for the first time

3:51 PM, Jan. 10, 2003

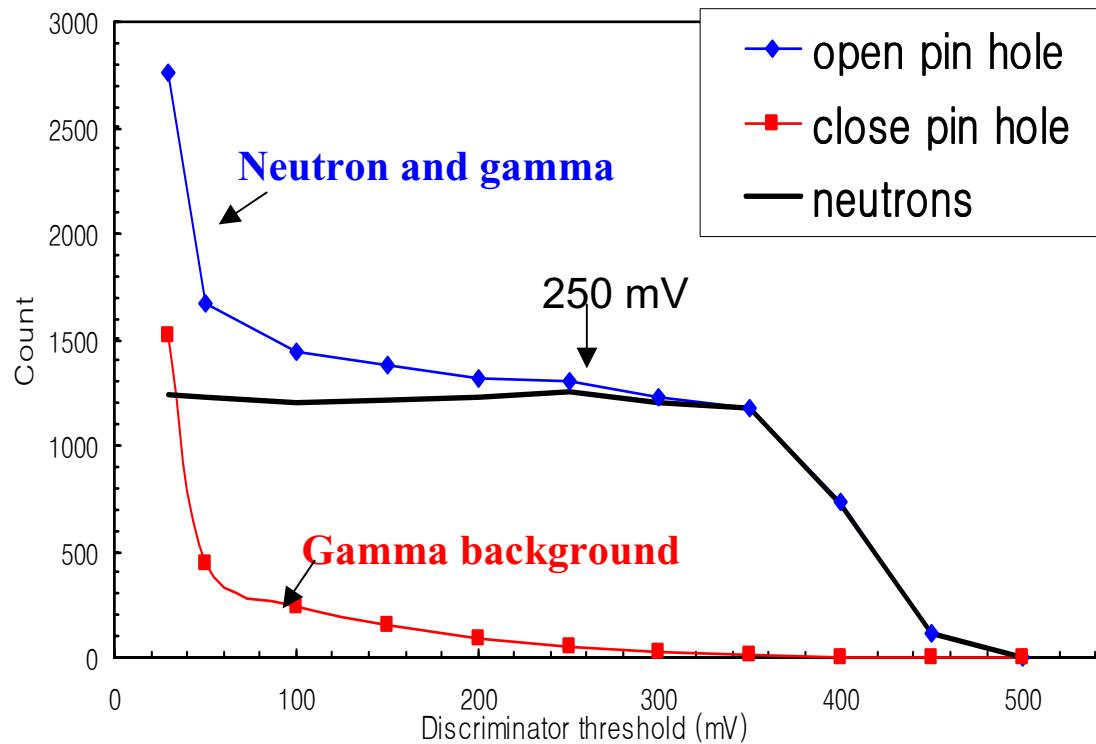
Schematic Diagram of Counting Electronics

1. Count neutrons defined by $\text{TOF}(t)$ and gate width(Δt)
2. Measure the beam current for normalization





Discriminator Threshold Selection

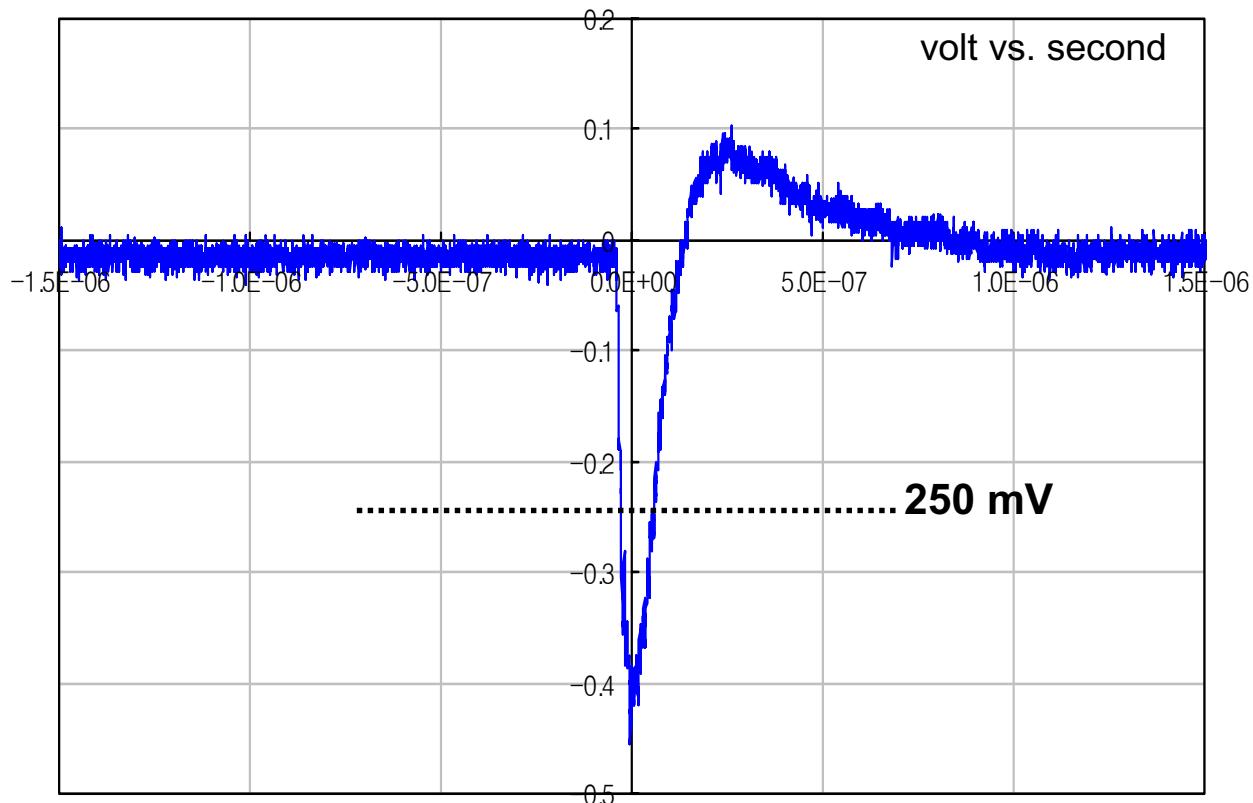


E=5meV

threshold (mV)	w/o Gd Rate (kHz)	w/ Gd Rate (kHz)	difference Rate (kHz)
500	0.01	0.00	0.01
450	0.36	0.00	0.36
400	2.28	0.01	2.28
350	3.70	0.03	3.70
300	3.85	0.09	3.85
250	4.08	0.17	4.08
200	4.10	0.28	4.10
150	4.29	0.49	4.29
100	4.52	0.74	4.52
50	5.22	1.39	5.22
30	8.62	4.74	8.60

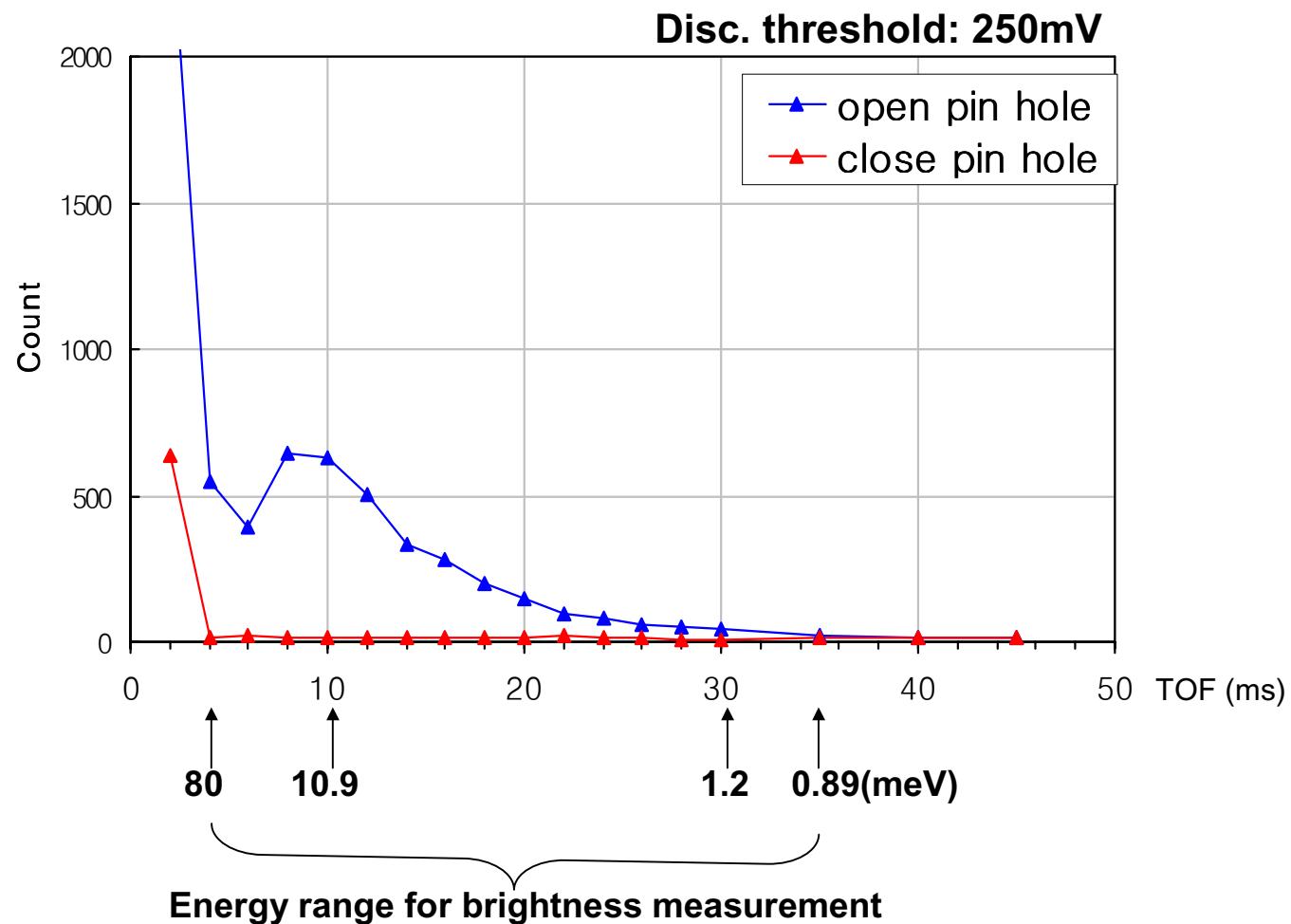
- Why can't we accept all signals from the detector?
- Why it's important to set the discriminator threshold in plateau region?
- What does the plateau mean?

Waveform of the Timing Amplifier Output



**Dead time < 1 μ s
Dead time losses ~ 1 μ s \times 4kHz=0.4%**

Time-of-Flight Spectra



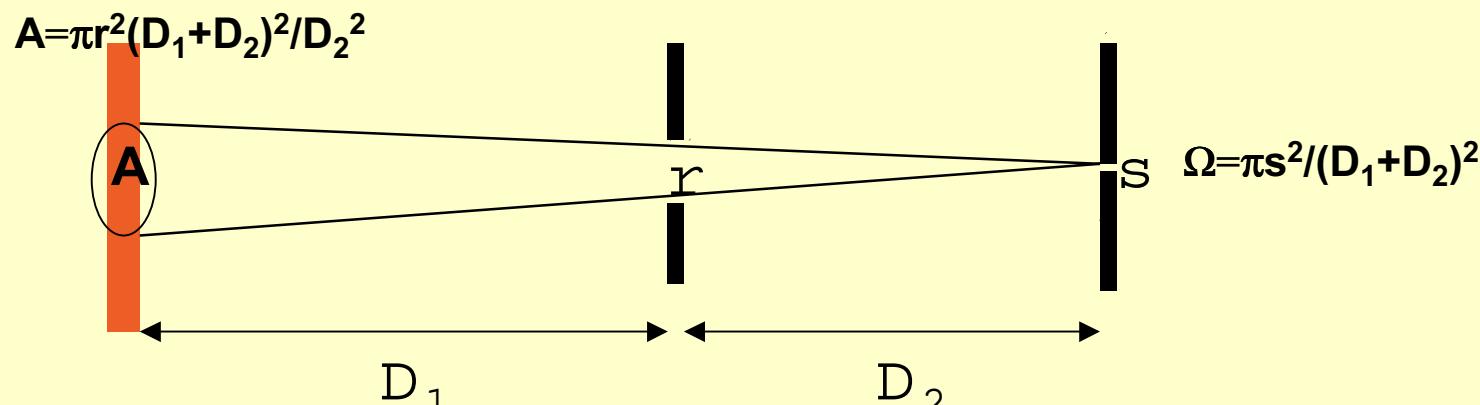
$$\text{Brightness} = n/\text{meV/s}/\mu\text{A}/\text{cm}^2/\text{sr}$$

normalized with proton current

$$\frac{(N - B)}{\text{Active time}} \left(\frac{n/\text{ms/pulse}}{\text{Active time}} \right) \times \frac{T}{2E} \left(\frac{\text{ms/meV}}{2E} \right) \rightarrow [n/\text{meV/pulse}]$$

$$[n/\text{meV/pulse}] \times 20 \text{ pulses/s} \times \frac{1}{\text{Proton current } (\mu\text{A})} \times \frac{1}{\Omega A}$$

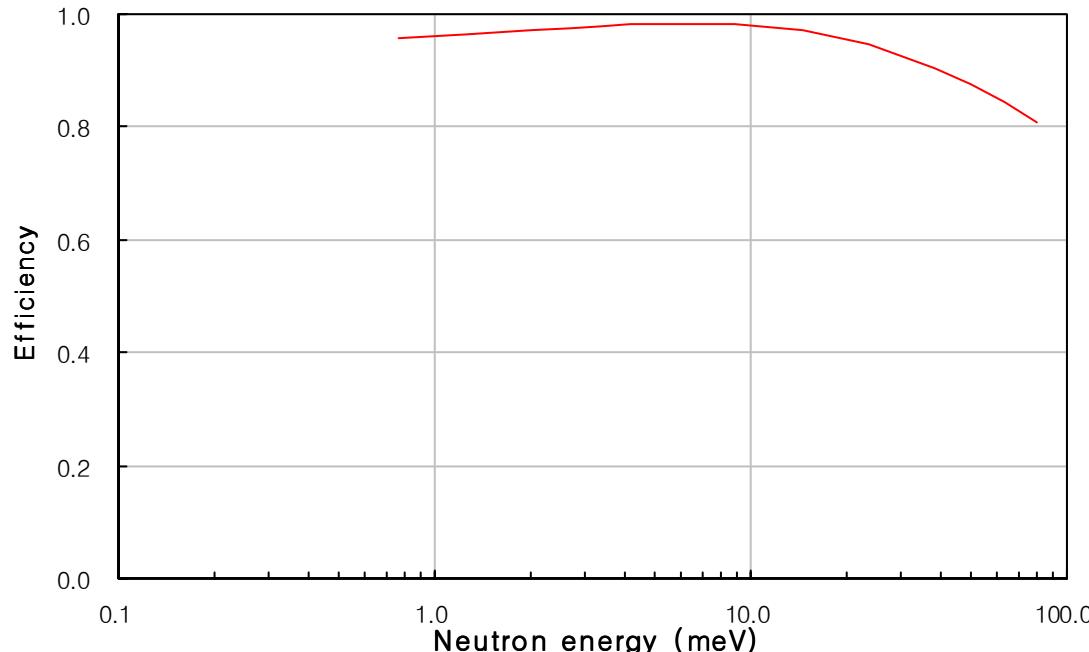
Two-pin-hole system



$$\Omega A = \pi s^2 \pi r^2 / D_2^2$$

Detector view on the moderator has 1.6-cm diameter

Efficiency of the ${}^6\text{Li}$ Scintillation Detector



$$\text{attenuation} = e^{-\sigma n x}$$

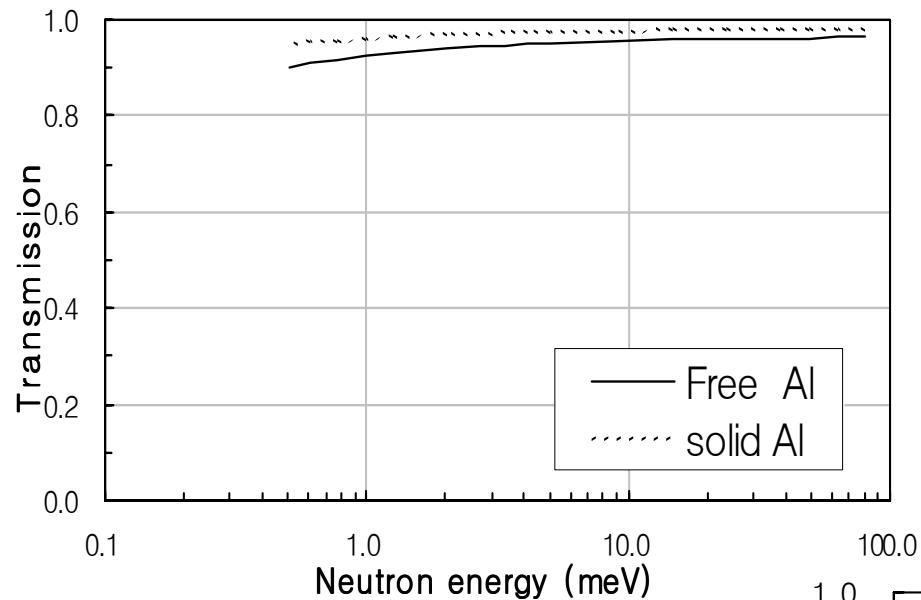
$$\sigma(b) = \frac{149}{\sqrt{E(\text{eV})}} \text{ for } {}^6\text{Li}(n,\alpha) \quad [\text{Ref. 1}]$$

$$\text{efficiency} = (1 - e^{-0.0156\sigma x}) \times \text{collection efficiency} \quad [\text{Ref. 2}]$$

Ref. 1: J.A. Harvey *et al.*, Nucl. Inst. Meth. 162, 507 (1979)

Ref. 2: N.R. Roberson *et al.*, Nucl. Inst. Meth. A326, 549 (1993)

Al transmission



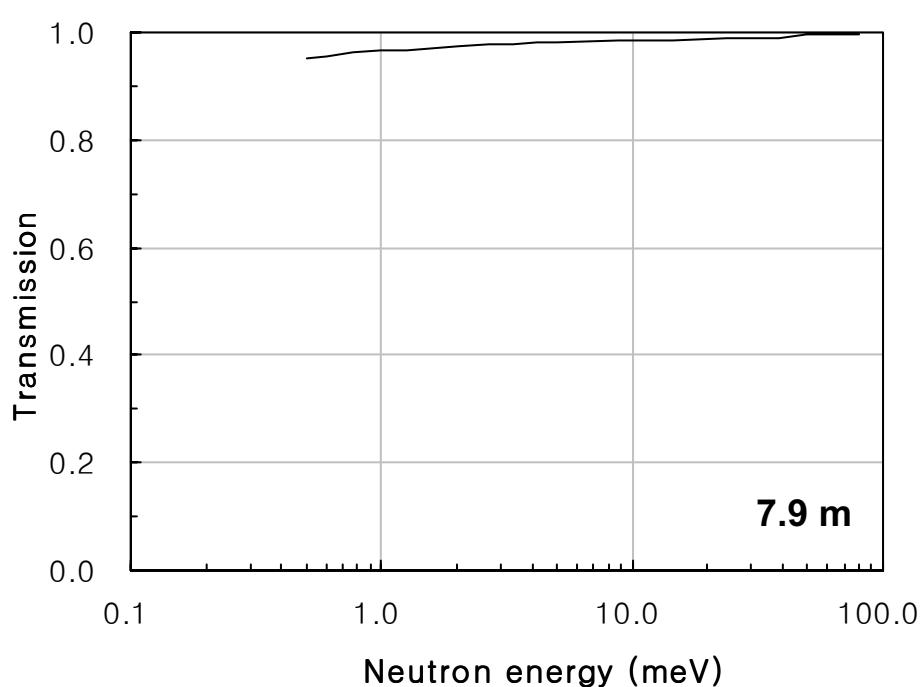
4.17mm Al window thickness

$$\text{attenuation} = e^{-\sigma n x}$$

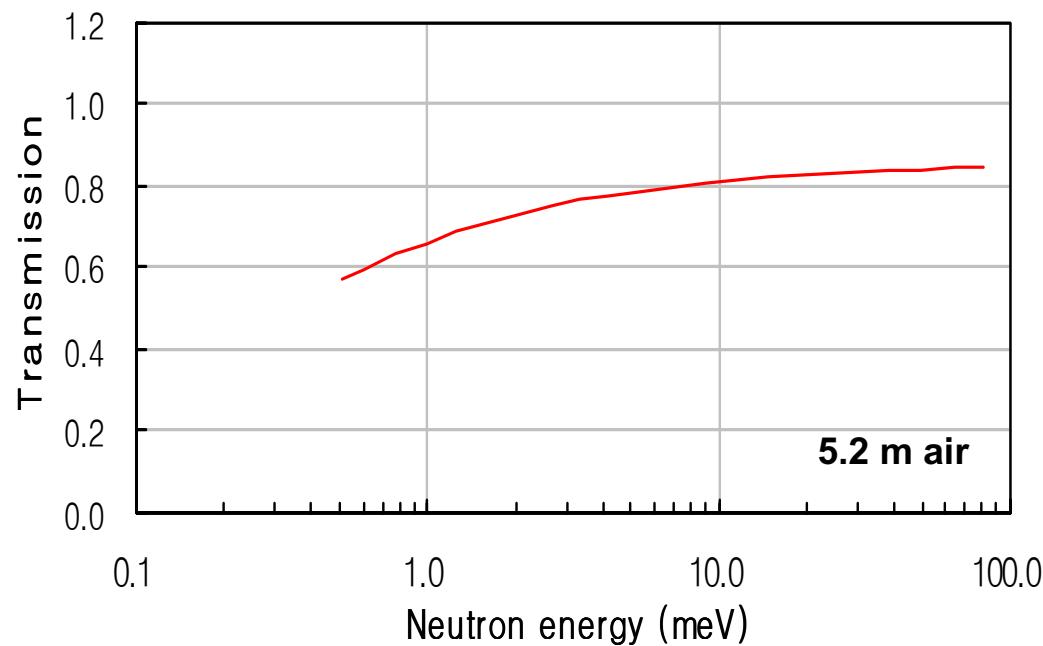
σ : total neutron cross section in barn
n: concentration in atoms/cm³
x: thickness in cm

$$\text{transmission} = 1 - \text{attenuation}$$

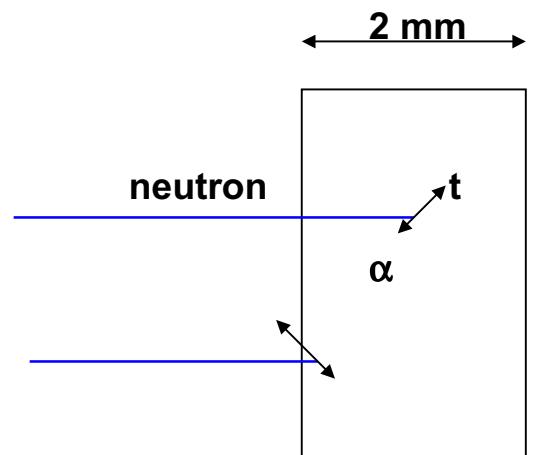
⁴He transmission



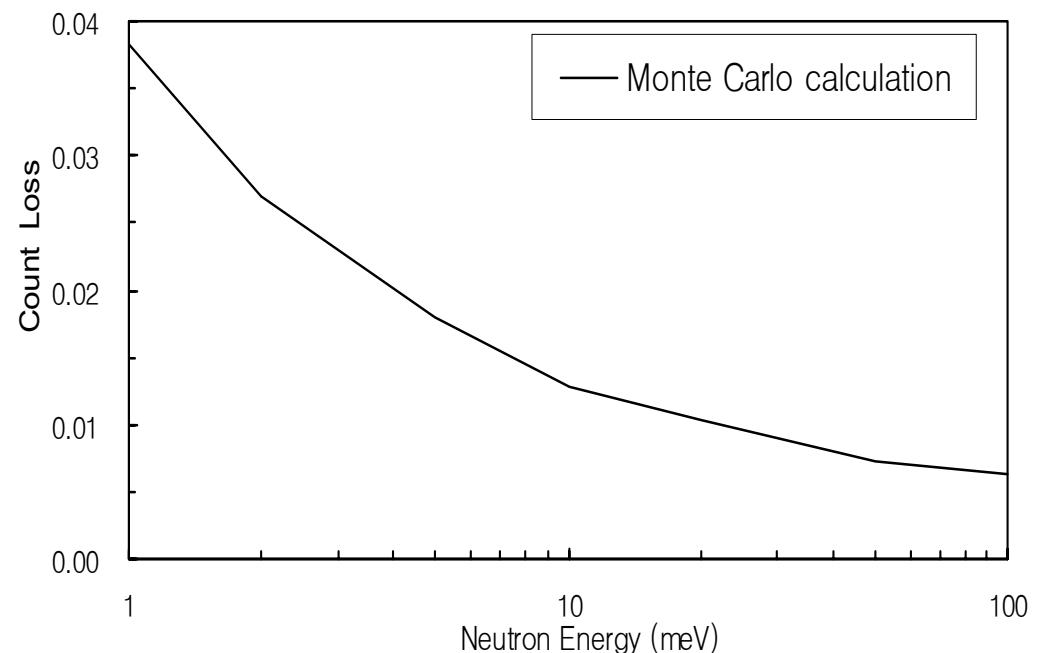
Air transmission



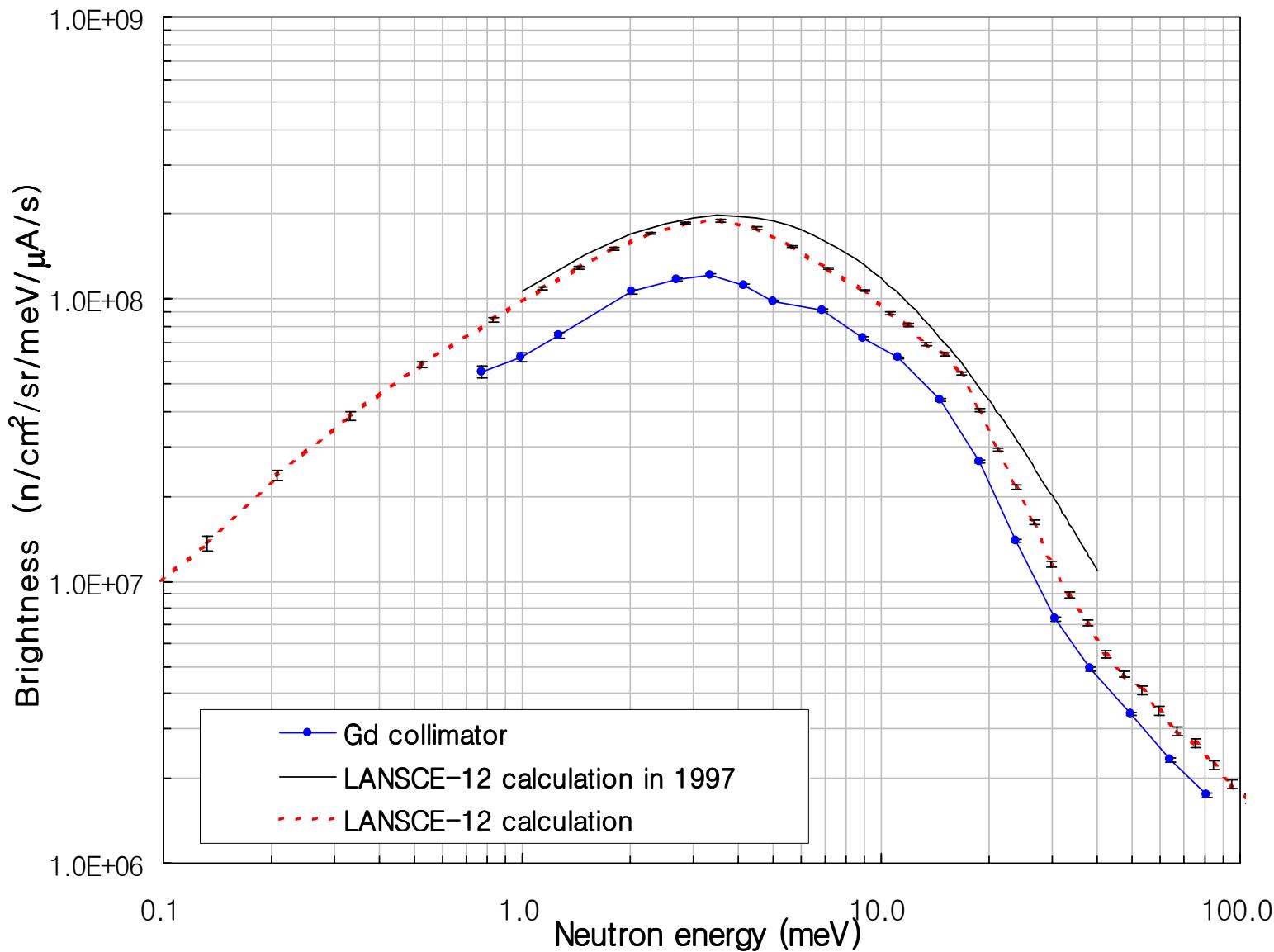
Loss of counts from escape of triton or α



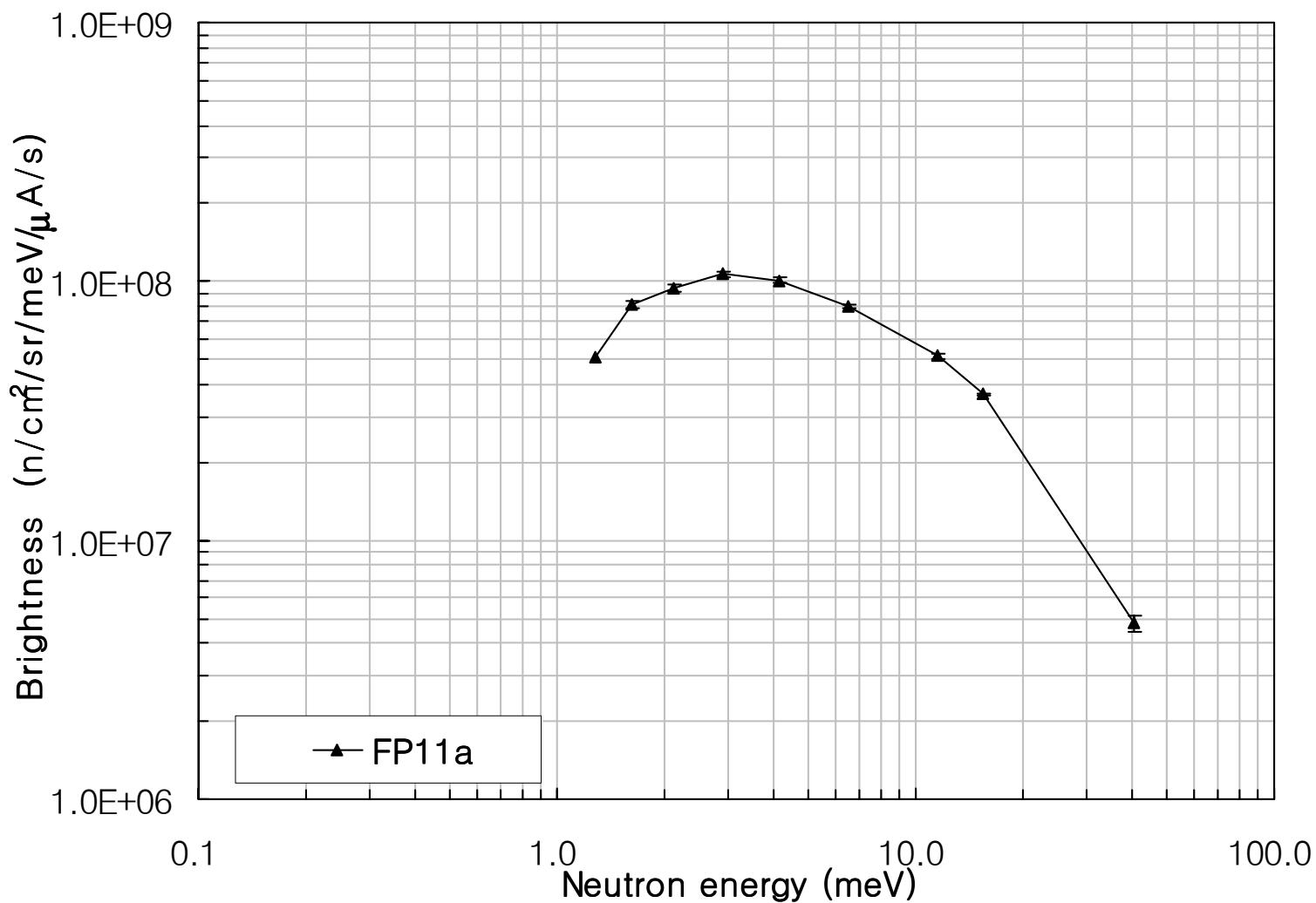
Ranges of alpha/triton: 6.9/38.7 μm



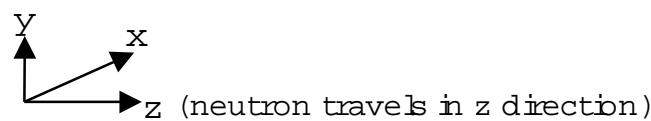
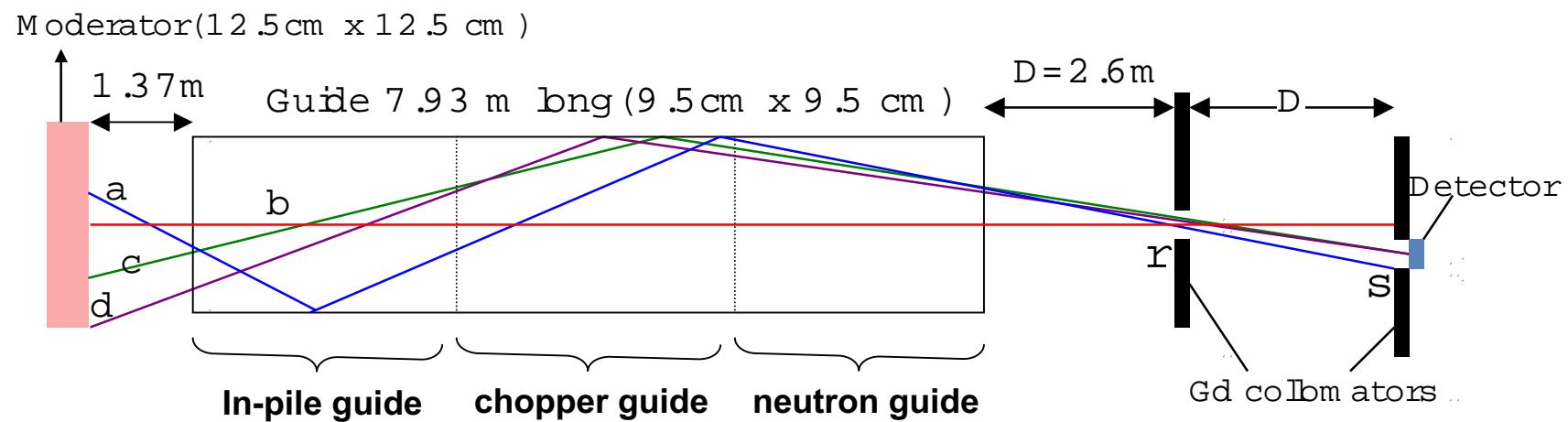
Brightness of FP12 Upper-tier Moderator (Jan. 2003)



Brightness Measurement of FP11a Lower-tier Moderator (Sep. 2000)

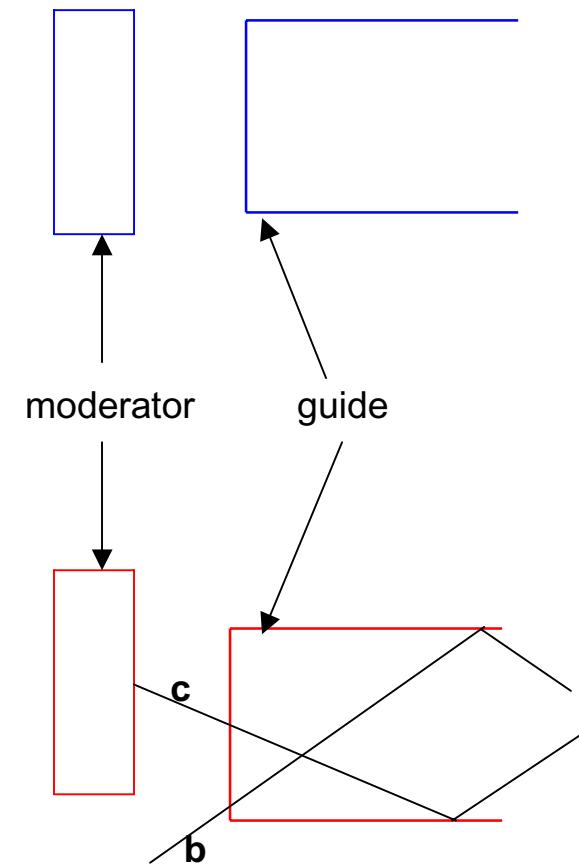
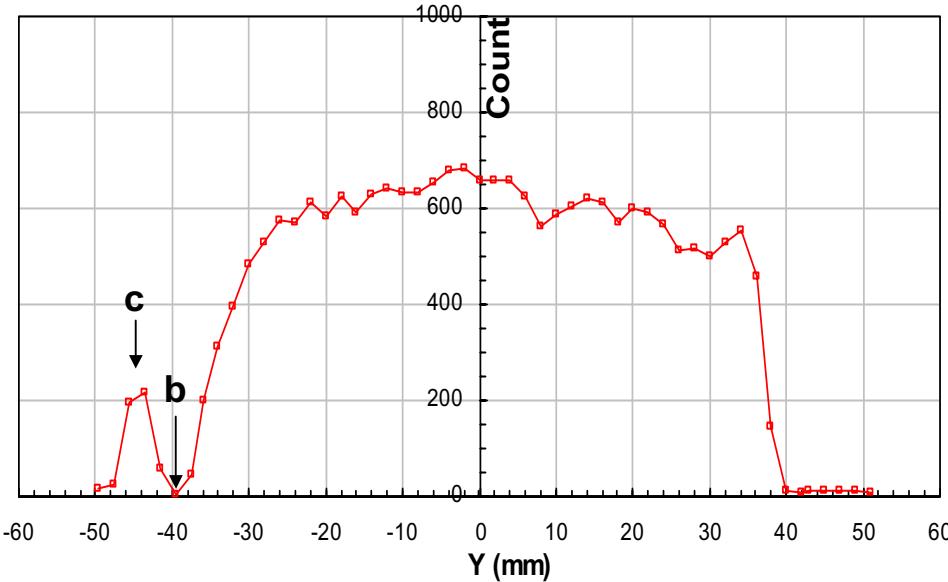
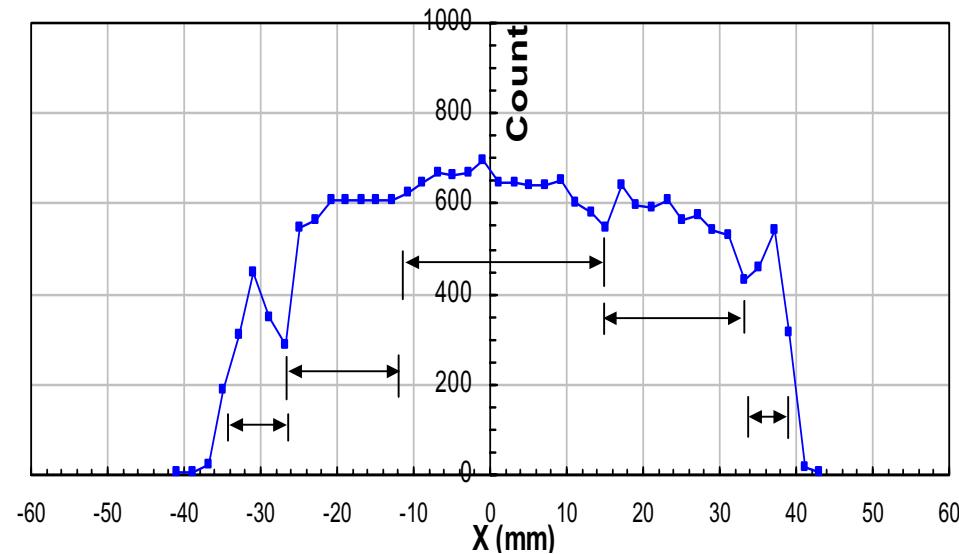


FP12 m=3 Guide Performance



X and Y Scan of the FP12 Moderator for 10 meV

m=3 cutoff near ± 40 mm in x and y



Conclusions

1. Brightness was measured for 0.8 – 81meV neutron energy.
Max. Brightness: **1.22E8 n/cm²/s/meV/sr/µA** at 3.3meV
Statistic error: ±2%, Systematic error: ±7%
2. m=3 Guide performed as expected.
3. L/R scan result concludes that moderator is well centered.
U/D scan result shows that the moderator is 1cm up.
4. For FP11a, Max. Brightness: **8.62E7 n/cm²/s/meV/sr/µA** at 3meV
5. Look forward to discussion of how the measurement can be used to improve moderator performance
6. Meaning of this measurement to NPDGamma experiment.